COMPUTER ASSISTED ASSESSMENT OF WOUND APPEARANCE USING DIGITAL IMAGING

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Abstract – **This paper describes a digital image processing system for the analysis of colour in wound images under clinical conditions. The system uses a 3CCD array digital video camera together with a colour scale for reference. The accuracy of colour assessment was compared with clinicians' assessment of the amount of slough (necrotic tissue) in digital images. The system was found to be within the range of 10% in describing red hue values in red colour patches between different clinical sessions. There was agreement in 75% of the cases between clinicians' assessment of the amount of slough and a computer assessment using digital imaging. However, colour may not be sufficient to describe wound appearance accurately.**

I. INTRODUCTION

Leg ulcers are often painful and debilitating and about 1.8 per 1000 population develop the condition [1]. Long healing periods cause major costs in treatment for the National Health Service in the United Kingdom.
Objective assessment of healing progress is considered important for assessing treatment strategies, however, at present it is difficult to predict how well wounds are healing. A number of parameters have been suggested, such as odour, pain, wound size and appearance of surrounding tissue [2]. The appearance of wounds is considered an important factor in the assessment of healing progress. It has been suggested that analysis of wound colour may be of clinical value [3-6]. However, these studies included only a small number of wounds and either looked at the entire wound or a small section and did not necessarily use colour patches for reference. Some systems were operated under a special experimental setup, which may prove impractical in a day to day clinical routine.

II. AIM

The aim of this study was to develop and apply a computer system for analysis of wound images under clinical conditions. This includes assessment of colour variability between images taken under clinical conditions with a digital video system. The system would also be used to assess the amount of slough in leg ulcers.

III. METHODOLOGY

A. Image Acquisition

Images of leg ulcers on 30 patients were obtained using a digital video camera (Panasonic NVDX100 B, Matsushita Electric Industrial Co. Ltd., Japan). This camera incorporates three separate CCD arrays, one each for the red, green and blue colour plane. This arrangement provides good colour reproduction and reduces interference between neighbouring pixels [7].

A 10W video light was mounted on the video camera and used to improve lighting conditions. The camera was operated in still picture mode and images were acquired in true-colour and subsequently downloaded digitally to a PC workstation. A graduated scale with additional colour patches (FUJI Colour Scale) was held close to the wound in order to provide a means of colour reference as seen in Figure 1. This was used to compare the variability of colour values between different images.

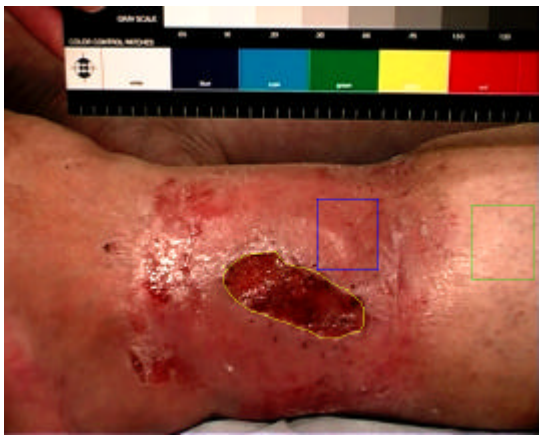

Fig 1: Example of wound image with colour scale

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Abstract

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B. Colour Model and Processing

Images taken from the camera were described by its Red, Green and Blue (RGB) components. In this colour model, however, the value of each component strongly depends on the light intensity which is influenced by different lighting conditions [8]. As suggested previously [6], the HSI (Hue, Saturation, Intensity) colour model was used in this study. Here, the intensity is separated from the other two components. Hue is the measure of wavelength of the main colour and represented by an angle [0°...360°], saturation is related to the amount of white light included, while the intensity is a measure of brightness.

Analysing hue as a non-continuous value causes problems numerically and hence the HSI colour model was modified by shifting the hue range to allow a continuous range of red hue values (120° - 180°) as seen in Table 1.

colour	hue range [°]	shifted hue' [°
red	330-30	120-180
yellow	30-90	180-240
green	90-150	240-300
turquoise	150-210	300-360
blue	210-270	0-60
violet	270-330	60-120

Table 1: HSI colour conversion table

IV. RESULTS

A. Colour Variability

Images were taken under clinical conditions in order to assess the variation in colour under not fully controlled lighting conditions. For example, some rooms in the clinic had daylight from windows while other rooms relied on fluorescent lighting. The variation of hue, saturation and intensity values in red colour patches of ten wound images was analysed. The red hue region in the HSI colour model ranges from 330° to 30° as shown in Table 1.

The range in hue values for the red colour patch held close to 10 wounds was analysed. The range of values occurring in the red colour patch was compared to the range of hue values occurring within each wound region. Hue values were mapped (Hue -> Hue´) according to Table 1.

The total range of hue values observed over the 10 wounds was 110°-190° and extended over the whole range of red into yellow.

	Median		
	min	max	% of range
Red Hue	144	150	10
Saturation	69	99	30
Intensity	168	240	28

Table 2: Range of median values in 10 images of a red colour patch.

The range of the scale for the red hue was 60 degrees, the range of saturation was 100% and the range of intensity was 255. Table 2 shows the median and range of hue, saturation and intensity values in 10 images of a red colour patch. The hue components expressed the least variation with 10% over its range. Saturation and intensity expressed a much higher variation of up to 30% between images of the same colour patch.

B. Assessment of wound slough

This part of the study was conducted to investigate the feasibility of using a digital video camera system to assess the colour appearance of wound images. More specifically, the image processing system was used to quantify the amount of slough in leg ulcers.

Thirty wound images were shown in random order to three experienced clinicians who graded images according to amount of slough they perceived. Five images were shown twice in order to test intra-observer variability.

Grading was performed according to the Table 3 below.

Grade	Rating
1	clean wound, no slough
2	minimal slough
3	moderate slough
4	moderate to heavy slough
5	heavy slough

Table 3: Clinicians grading table for assessment of slough in wound images

The wound area was delineated using an adaptive spline technique by placing a few salient points onto the wound boundary [9]. The computer interpolated the boundary between control points to form a smooth boundary representation. Points could be adjusted by moving them to a new location such that the boundary was described closely. The area within the spline was used as a region of interest and within that region the amount of slough was calculated in relation to the overall size of the region.

The amount of slough was calculated from the hue values between two thresholds T_1=180° and T_2=240° of the shifted hue scale in Table 1. These threshold values were determined after consulting the clinicians' perception of slough colour.

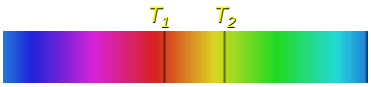

Fig 2: Colour scale and thresholds

Figure 2 shows the two thresholds on the shifted hue colour scale. Pixel values with an excessive intensity (I > 0.9), indicating specula reflection, were excluded. Also, dark regions were excluded (I < 0.1). The following two images in Figure 3 show two examples of wounds expressing different amounts of slough.

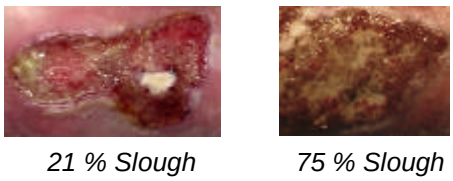

Fig 3: Example of two images with different amount of slough

The percentage values obtained from the image analysis were mapped in a linear fashion onto a grading system with five grades as shown in Table 3. For example, in this mapping function 20% to 39% of slough would correspond to the grade 'minimal slough'.

Thirty images were assessed and classified into five categories by three experienced clinicians at random. In five cases there was full agreement (16.6%) between the three clinicians while in a further 19 cases (63.3%) there was a difference of only one grade where the two other clinicians agreed. Six cases did not experience any agreement (20%).

The result of the 24 wound images from the clinicians assessment, where at least two clinicians agreed, was compared against the results from the image analysis. In 12 cases (50%), the colour analysis expressed the same grade as the clinicians' assessment while in a further six cases (25%) the result suggested by the image analysis was only one grade different from the clinicians assessment. In six cases (25%), however, the image processing technique and the clinicians' assessment was different by more than one grade.

V. DISCUSSION

The results suggest that recording images digitally on a 3CCD chip camera is a feasible way of determining wound colours under clinical condition. Despite the influence of daylight and/or fluorescent light, there was a maximum shift of six degrees (10%) in hue in the red colour patches. Intensity and saturation expressed a greater variation of up to 30%. Hue appears to be the most stable component of the HSI colour model for colour analysis which was also used in previous studies [4]. However, it also shows that colour reference is likely to be necessary to obtain reliable results in order to be able to describe subtle changes in hue.

Image processing may provide a tool to assess objectively colour appearance of wound images. The system developed was used to quantify the amount of slough in leg ulcer images. We observed agreement in 75% of the cases between clinicians' assessment and the computer analysis. The assessment of wound appearance from digital images alone, however, seemed not to be sufficient for experienced clinicians. Clinicians take many other factors into account, such as the patients' history, odour, pain, size and surrounding tissue [2]. However, the system may contribute to a more objective assessment of colour in wound images taken under clinical conditions.

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